4.0 RESULTS, ANALYSES, AND RECOMMENDATIONS

This section describes the results and data analyses and includes a discussion of probable constituent sources and recommendations.

4.1 Hydrology – Precipitation and Flow

4.1.1 Analysis of Precipitation and Flow Data and a Discussion of the Hydrographs

This subsection discusses the precipitation and flow data and the hydrologic analysis of the monitoring area. Precipitation data and hydrographs can be used to address the following management question:

How did the 2014-2015 storm season differ in comparison to previous storm seasons?

This management question is answered in the following two ways:

1. Figure 4-1 illustrates total precipitation by storm season observed in downtown Los Angeles at Station 716, Ducommun Street. The total annual rainfall during the 2014-2015 storm season in downtown Los Angeles was approximately two-thirds of the 143-year average annual rainfall and was the fourth storm season in a row with below average precipitation totals.

2. Figure 4-2 is a comparison of the total monthly rainfall for the 2014-2015 storm season and the long-term pattern of rainfall observed in downtown Los Angeles at Station 716, Ducommun Street. During the 2014-2015 storm season, rainfall was less than the 143-year historic rainfall average for every month except December 2014 and September 2015. December had the highest monthly rainfall total of the 2014-2015 monitoring year. Only a little over a half inch of rain fell during February, historically the wettest month. The historic seasonal pattern of rainfall includes an increase in precipitation in October, November, and December that peaks in January and February before decreasing during March, April, and May. The seasonal pattern observed for the 2014-2015 monitoring year differed from the historic pattern, due to the relatively dry conditions observed in January and February as well as the higher than average rainfall observed in September.

4.1.2 Hydrographs for Monitoring Stations

Hydrographs are provided for all monitoring station events for which flow-weighted composite samples were collected during the 2014-2015 monitoring season (Appendix A). Each hydrograph includes the known times of the composite sample aliquot collection, including the first and last aliquots, sample volume interval, runoff volume, and percent of storm sampled. A summary of the hydrologic data for the MES is provided in Table 4-1.

The hydrographs and composite sampling start and end times can be used to address the following management question:

What percentage and what portion of the storm event were sampled?

This question is answered by examining the hydrographs (Appendix A). Each hydrograph contains the percent of the storm that was sampled and the first and last composite samples, which provides a visual representation of the sampled portion of the storm. Whenever possible, the initial portion of the event was sampled, rather than the tailing end of the hydrographs. Good faith effort was made to capture composite samples most representative of the full duration of each monitored storm event. While the sampled portion of the storm varied widely based on individual site conditions, the average percent of the storm that was sampled was 76% (does not include S29 which was sampled for the first three hours of each storm, in accordance with the 2001 Monitoring Program).

4.2 Water Quality Objectives

This subsection and the following subsection address the following key management question:

What constituents were measured at concentrations that do not meet water quality objectives?

Water quality standards consist of defined beneficial uses of water and numeric or narrative water quality objectives (WQOs) used to evaluate whether beneficial uses are protected. Numeric water quality objectives are expressed in the following terms:

- Magnitude – Defined as the threshold concentration at which beneficial uses are threatened or impaired.
- Frequency – Defined as the number of exceedances of threshold concentrations in a given time period that indicates impairment.
- Duration – Defined as the length of time the ecosystem is exposed to concentrations above the threshold.

Analyses that compare measurements to objectives consider magnitude. Aquatic life objectives established in the California Toxics Rule (CTR), 40 Code of Federal Regulations (CFR) Part 131, also include an exceedance frequency of no more than once every three years (EPA, 2000). Human-health-based objectives, such as mercury in the CTR or maximum contaminant levels (MCLs) cited in the Water Quality Control Plan for the Los Angeles Region (Basin Plan) (LARWQCB, 1994), do not specify an exceedance frequency.

The duration for many objectives for aquatic life are usually expressed as acute (i.e., one-hour exposure) or chronic (i.e., four-day exposure). In the CTR, acute objectives for aquatic life are expressed as Criterion Maximum Concentrations (CMC) while chronic objectives are expressed as Criterion Continuous Concentrations (CCC). Other objectives (e.g., human health criteria in the CTR) are expressed as instantaneous thresholds.

For monitoring conducted during the 2014-2015 monitoring year, analyses performed were based on instantaneous grab samples or composite samples. For dry weather analyses, 24-hour composite samples were used. Comparisons to applicable Basin Plan objectives and CTR acute water quality objectives (CMCs) were made for all samples.

Applicable water quality objectives used in this assessment, which are not sample specific, are listed in the tables below by station. Sample specific WQOs that are based on calculations for sample-specific conditions are listed as ranges in Tables 4-4 and Table 4-5 (summary of water quality data for mass emission and tributary stations, respectively). Examples of these sample-specific objectives include ammonia water quality objectives that are based on sample pH and are determined using measured pH and Table 3-1 of the Basin Plan; dissolved metals water quality objectives that are calculated using measured sample hardness and procedures set forth in the CTR; and pentachlorophenol water quality objectives that are calculated based upon sample pH values and procedures set forth in the CTR.

Water Quality Objectives at Mass Emission Stations

Constituent	Units	Water Quality Objective Source	Station ID						
			S01	S02	S10	S13	S14	S28	S29
4-4'-DDT	µg/L	CTR CMC	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Aldrin	µg/L	CTR CMC	3	3	3	3	3	3	3
Chloride	mg/L	Basin Plan	NA	500	150	NA	150	NA	150
Cyanide	mg/L	CTR CMC	0.022	0.022	0.022	0.022	0.022	0.022	0.022
Dieldrin	µg/L	CTR CMC	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Dissolved arsenic	µg/L	CTR CMC	340	340	340	340	340	340	340
Dissolved oxygen (DO)	mg/L	Basin Plan	5	7	5	5	5	5	5
E. coli	MPN/ 100 mL	Basin Plan	576	235	235	235	235	235	235
alpha-Endosulfan	µg/L	CTR CMC	0.22	0.22	0.22	0.22	0.22	0.22	0.22
beta-Endosulfan	µg/L	CTR CMC	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Endrin	µg/L	CTR CMC	0.086	0.086	0.086	0.086	0.086	0.086	0.086
gamma-BHC (lindane)	µg/L	CTR CMC	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Heptachlor	µg/L	CTR CMC	0.52	0.52	0.52	0.52	0.52	0.52	0.52
Heptachlor epoxide	µg/L	CTR CMC	0.52	0.52	0.52	0.52	0.52	0.52	0.52
Nitrate (NO_3)	mg/L	Basin Plan	45	45	45	45	45	45	45
Nitrate-N	mg/L	Basin Plan	10	10	10	10	10	10	10
Nitrite-N	mg/L	Basin Plan	1	1	1	1	1	1	1
pH	pH units	Basin Plan	6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5
Sulfate	mg/L	Basin Plan	NA	500	350	NA	300	NA	600
Total dissolved solids (TDS)	mg/L	Basin Plan	NA	2,000	1,500	NA	750	NA	1,200
Toxaphene	µg/L	CTR CMC	0.73	0.73	0.73	0.73	0.73	0.73	0.73

NA = not applicable.
µg/L = microgram per liter
MPN = most probable number.
CTR = California Toxics Rule.
mg/L = milligram per liter.
mL = milliliter.
CMC – Criterion Maximum Concentration

Water Quality Objectives at Tributary Stations

Constituent	Units	Water Quality Objective Source	Station ID					
			TS25	TS26	TS27	TS28	TS29	TS30
4-4'-DDT	µg/L	CTR CMC	1.1	1.1	1.1	1.1	1.1	1.1
Aldrin	µg/L	CTR CMC	3	3	3	3	3	3
Chloride	mg/L	Basin Plan	500	500	500	500	500	500
Cyanide	mg/L	CTR CMC	0.022	0.022	0.022	0.022	0.022	0.022
Dieldrin	µg/L	CTR CMC	0.24	0.24	0.24	0.24	0.24	0.24
Dissolved arsenic	µg/L	CTR CMC	340	340	340	340	340	340
Dissolved Oxygen (DO)	mg/L	Basin Plan	5	5	5	5	5	5
E. coli	MPN/100 mL	Basin Plan	235	235	235	235	235	235
alpha-Endosulfan	µg/L	CTR CMC	0.22	0.22	0.22	0.22	0.22	0.22
beta-Endosulfan	µg/L	CTR CMC	0.22	0.22	0.22	0.22	0.22	0.22
Endrin	µg/L	CTR CMC	0.086	0.086	0.086	0.086	0.086	0.086
gamma-BHC (lindane)	µg/L	CTR CMC	0.95	0.95	0.95	0.95	0.95	0.95
Heptachlor	µg/L	CTR CMC	0.52	0.52	0.52	0.52	0.52	0.52
Heptachlor epoxide	µg/L	CTR CMC	0.52	0.52	0.52	0.52	0.52	0.52
Nitrate (NO_3)	mg/L	Basin Plan	45	45	45	45	45	45
Nitrate-N	mg/L	Basin Plan	10	10	10	10	10	10
Nitrite-N	mg/L	Basin Plan	1	1	1	1	1	1
pH	pH units	Basin Plan	6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5
Sulfate	mg/L	Basin Plan	500	500	500	500	500	500
Total Dissolved Solids (TDS)	mg/L	Basin Plan	2,000	2,000	2,000	2,000	2,000	2,000
Toxaphene	µg/L	CTR CMC	0.73	0.73	0.73	0.73	0.73	0.73

µg/L = microgram per liter
MPN = most probable number.
CTR = California Toxics Rule.
mg/L = milligram per liter.
mL = milliliter.
CMC – Criterion Maximum Concentration

4.2.1 Bacteria Water Quality Objectives

Water quality objectives for indicator bacteria are based on the recreation (REC) beneficial use designation at each station. The Basin Plan Amendment – Resolution No. R10-005 (Update of the Bacteria Objectives for Freshwaters Designated for Water Contact Recreation), was adopted December 5, 2011, and removed the fecal coliform water quality objectives for the beneficial uses REC-1 (water contact recreation – full immersion) and LREC-1 (limited contact recreation) (LARWQCB, 2010).

Since the adoption of Resolution R10-005 in 2011, the REC-1 water quality objective for bacteria is 235 MPN/100 mL of *E. coli*, and the LREC-1 water quality objective for bacteria is 576 most probable number in 100 milliliters (MPN/100 mL) of *E. coli*. The REC-2 (non-contact recreation) water quality objective of 4,000 MPN/100 mL of fecal coliform applies to waters that are not also designated for water contact recreation (REC-1). The table below summarizes the recreational beneficial uses by station among the watersheds monitored.

Summary of Recreational Beneficial Uses and Applicable Bacteria Water Quality Objectives

Station ID	Station Name	High Flow Suspension	REC-1	LREC-1	REC-2	Applicable *E. coli* WQO (MPN/100 mL)
S01	Ballona Creek	X	P*	E	E	576
S02	Malibu Creek		E		E	235
S10	Los Angeles River	X	E		E	235
S13	Coyote Creek	X	P		I	235
S14	San Gabriel River	X	E		E	235
S28	Dominguez Channel	X	P		E	235
S29	Santa Clara River		E		E	235
TS25	Upper Las Virgenes		E		E	235
TS26	Cheseboro Canyon		E		E	235
TS27	Lower Lindero Creek		I		I	235
TS28	Medea Creek		E		E	235
TS29	Liberty Canyon Channel		E		E	235
TS30	PD 728		I		I	235

*- The REC-1 use designation does not apply to recreational activities associated with the swimmable goal or the associated bacteriological objectives.
E- Existing beneficial use
P – Potential beneficial use
I – Intermittent beneficial use
MPN = most probable number.
WQO = water quality objective.
mL = milliliter.

4.2.1.1 High Flow Suspension

Basin Plan Amendment – Resolution No. 2003-010 (High-Flow Suspension of Recreational Uses) was adopted November 2, 2004 (LARWQCB, 2003). The High Flow Suspension suspends recreational beneficial uses (REC-1, LREC-1, and REC-2) and the associated bacteria water quality objectives during wet weather storm events with rainfall greater than 0.5 inch in 24 hours. This suspension only applies to engineered channels, identified in Table 2-1a of the Basin Plan.

The storm events for which the high flow suspension applied during 2014-2015 are identified in the exceedance summary in Subsection 4.3 for each drainage area as well as in Table 4-1, Summary of Hydrologic Data for Mass Emissions Stations. The high-flow suspension was applied at one or more of the MES during three storms events monitored during the 2014-2015 season. Measurements above the bacteria water quality objective were not highlighted for these events.

4.3 2014-2015 Monitoring Results

The following sections summarize the constituents that did not meet applicable water quality objectives at MES and tributary stations sampled during the 2014-2015 Monitoring Program. Results are grouped by wet weather or dry weather, and by watershed. Specific results are available in Appendix B for all stations and sampling events.

Additionally, a summary of the water quality monitoring data is presented in Table 4-4 and Table 4-5 for the MES and tributary stations, respectively. Figures 4-3.1 through 4-6.6 provide a graphical summary of water quality data for all MES and tributary stations, respectively. Wet weather monitoring data are shown on Figures 4-3.1 through 4-4.6, and dry weather monitoring data are shown on Figures 4-5.1 through 4-6.6. For each station, the constituents are represented as the ratio of the concentration measured during the monitoring event to the applicable water quality objective. For instance, if the total dissolved solids (TDS) concentration for a given storm was 2,000 milligrams per liter (mg/L) and the water quality objective was 2,000 mg/L at that location, then the ratio would be 1 on the graph.

4.3.1 Mass Emission Stations During Wet Weather

4.3.1.1 Ballona Creek (S01)

A summary of the constituents that did not meet applicable water quality objectives at the Ballona Creek MES during the 2014-2015 Wet Weather Monitoring Season is presented in Table 4-4.1 and Figure 4-3.1.

E. coli concentrations ranged from 34,500 to 57,940 MPN/100 mL and were above the water quality objective of 576 MPN/100 mL during all three events monitored for bacteria. The highest *E. coli* concentration at Ballona Creek was measured during 2014-15Event04. During wet weather high-flow periods, Ballona Creek is subject to a suspension of the recreational beneficial uses. As a result of this suspension, *E. coli* concentrations above 576 MPN/100 mL are not highlighted for 2014-15Event09 and 2014-15Event10. Based on this assessment, one of the three wet weather events analyzed for bacteria (2014-2015Event04) did not meet the *E. coli* water quality objective (Table 4-4.1 and Figure 4-3.1).

Several metals were above their corresponding hardness-based water quality objectives for at least one wet weather sample collected at Ballona Creek (Table 4-4.1). Dissolved copper concentrations ranged from 43.7 to 95.6 micrograms per liter (μg/L) and were above the water quality objective for all three of the wet weather samples collected at Ballona Creek. Dissolved zinc was also above the hardness-based water quality objective for all three wet weather samples, with concentrations ranging from 286 to 970 μg/L. Dissolved lead concentrations ranged from 24.8 to 93.0 μg/L, and two of the three concentrations (measured during 2014-15Event04 and 2014-15Event10) were above the hardness-based water quality objective. Hardness values for samples collected during wet weather at Ballona Creek ranged from 50 to 135 mg/L.

Dissolved oxygen concentrations ranged from 3.71 to 9.68, and one of the three values (measured during 2014-15Event04) was below the water quality objective of 5 mg/L (Table 4-4.1).

pH values ranged from 6.31 to 7.24 and were slightly below the lower limit of the water quality objective range of 6.5–8.5 pH units for one of the three wet weather samples (Table 4-4.1).

Nitrite as N concentrations ranged from <0.1 to 3.45 mg/L. One of the three values (measured during 2014-15Event04) was above the water quality objective of 1.0 mg/L (Table 4-4.1).

All other applicable water quality objectives at the Ballona Creek MES were met during the 2014-2015 Wet Weather Monitoring Season.

4.3.1.2 Malibu Creek (S02)

A summary of the constituents that did not meet applicable water quality objectives at the Malibu Creek MES during the 2014–2015 Wet Weather Monitoring Season is presented in Table 4-4.2 and Figure 4-3.2. Runoff remained at baseflow throughout the first storm of the monitoring season (2014-15Event04); therefore samples were not collected at the Malibu Creek MES during that event.

E. coli bacteria concentrations ranged from 146 to 21,100 MPN/100 mL, and two of the three values (measured during 2014-15Event08 and 2014-15Event09) were above the applicable water quality objective of 235 MPN/100 mL (Table 4-4.2 and Figure 4-3.2). The highest *E. coli* concentration at Malibu Creek was measured during 2014-15Event08. Malibu Creek is not subject to the high flow suspension of the recreational beneficial uses.

Sulfate concentrations ranged from 392 to 739 mg/L. One of the three values (measured during 2014-15Event08) was above the water quality objective of 500 mg/L (Table 4-4.2).

All other applicable water quality objectives at the Malibu Creek MES were met during the 2014-2015 Wet Weather Monitoring Season.

4.3.1.3 Los Angeles River (S10)

A summary of the constituents that did not meet applicable water quality objectives at the Los Angeles River MES during the 2014-2015 Wet Weather Monitoring Season is presented in Table 4-4.3 and Figure 4-3.3. TSS was not sampled at the Los Angeles River MES during 2014-15Event08 due to equipment failure.

E. coli concentrations ranged from 54,600 to 178,900 MPN/100 mL and were above the water quality objective of 235 MPN/100 mL during all three storm events monitored for bacteria at Los Angeles River. The highest *E. coli* concentration at Los Angeles River was measured during 2014-15Event04. During wet weather high-flow periods, Los Angeles River is subject to a suspension of the recreational beneficial uses. As a result of this suspension, *E. coli* concentrations above 235 MPN/100 mL are not highlighted for 2014-15Event09 or 2014-15Event10. Based on this assessment, one of the three wet weather events analyzed for bacteria (2014-15Event04) did not meet the *E. coli* water quality objective (Table 4-4.3 and Figure 4-3.3).

Dissolved oxygen concentrations ranged from 1.56 to 9.38, and one of the three values (measured during 2014-15Event04) was below the water quality objective of 5 mg/L (Table 4-4.3).

Nitrite as N concentrations ranged from <0.1 to 1.44 mg/L. One of the three values (measured during 2014-15Event04) was above the water quality objective of 1.0 mg/L (Table 4-4.3).

Several metals were above their corresponding hardness-based water quality objectives for at least one wet weather sample collected at Los Angeles River (Table 4-4.3). Dissolved copper concentrations ranged from 45.4 to 155 µg/L and were above the water quality objective for all three of the wet weather samples collected at Los Angeles River. Dissolved zinc was also above the hardness-based water quality objective for all three wet weather samples, with concentrations ranging from 328 to 980 µg/L. Dissolved lead concentrations ranged from 30.0 to 88.0 µg/L, and one of the three concentrations (measured during 2014-15Event10) was above the hardness-based water quality objective. Hardness values for samples collected during wet weather at Los Angeles River ranged from 58 to 160 mg/L (Table 4-4.3).

All other applicable water quality objectives at the Los Angeles River MES were met during the 2014-2015 Wet Weather Monitoring Season.

4.3.1.4 Coyote Creek (S13)

A summary of the constituents that did not meet applicable water quality objectives at the Coyote Creek MES during the 2014-2015 Wet Weather Monitoring Season is presented in Table 4-4.4 and Figure 4-3.4.

E. coli concentrations ranged from 10,462 to 21,300 MPN/100 mL and were above the water quality objective of 235 MPN/100 mL during all three storm events monitored for bacteria at Coyote Creek. The highest *E. coli* concentration at Coyote Creek was measured during 2014-15Event04. During wet weather high-flow periods, Coyote Creek is subject to a suspension of the recreational beneficial uses. As a result of this suspension, *E. coli* concentrations above 235 MPN/100 mL are not highlighted for 2014-15Event09 or 2014-15Event10. Based on this assessment, one of the three wet weather events analyzed for bacteria (2014-2015Event04) did not meet the *E. coli* water quality objective (Table 4-4.4 and Figure 4-3.4).

Dissolved oxygen concentrations ranged from 2.9 to 9.7, and one of the three values (measured during 2014-15Event04) was below the water quality objective of 5 mg/L (Table 4-4.4).

Dissolved copper concentrations ranged from 20.0 to 52.8 µg/L and were above the hardness-based water quality objective for all three of the wet weather samples collected at Coyote Creek. Dissolved zinc was also above the hardness-based water quality objective for all three wet weather samples, with concentrations ranging from 143 to 472 µg/L. Hardness values for samples collected during wet weather at Coyote Creek ranged from 45 to 135 mg/L (Table 4-4.4).

All other applicable water quality objectives at the Coyote Creek MES were met during the 2014-2015 Wet Weather Monitoring Season.

4.3.1.5 San Gabriel River (S14)

A summary of the constituents that did not meet applicable water quality objectives at the San Gabriel River MES during the 2014-2015 Wet Weather Monitoring Season is presented in Table 4-4.5 and Figure 4-3.5.

E. coli concentrations ranged from 21,430 to 51,720 MPN/100 mL and were above the water quality objective of 235 MPN/100 mL during all three storm events monitored for bacteria at San Gabriel River. The highest *E. coli* concentration at San Gabriel River was measured during 2014-15Event04. During wet weather high-flow periods, San Gabriel River is subject to a suspension of the recreational beneficial uses. As a result of this suspension, *E. coli* concentrations above 235 MPN/100 mL are not highlighted for all three of the monitored wet weather events (2014-15Event04, 2014-15Event09 and 2014-15Event10) (Table 4-4.5 and Figure 4-3.5).

Cyanide concentrations ranged from <0.005 to 0.029 mg/L, and one of the three values (measured during 2014-15Event04) was above the water quality objective of 0.022 mg/L (Table 4-4.5).

Dissolved oxygen concentrations ranged from 2.91 to 9.2, and one of the three values (measured during 2014-15Event04) was below the water quality objective of 5 mg/L (Table 4-4.5).

Dissolved copper concentrations ranged from 8.78 to 21.5 μg/L and were above the hardness-based water quality objective for one of the three of the wet weather samples collected at San Gabriel River (measured during 2014-15Event09). Hardness values for samples collected during wet weather at San Gabriel River ranged from 90 to 213 mg/L (Table 4-4.5).

All other applicable water quality objectives at the San Gabriel River MES were met during the 2014-2015 Wet Weather Monitoring Season.

4.3.1.6 Dominguez Channel (S28)

A summary of the constituents that did not meet applicable water quality objectives at the Dominguez Channel MES during the 2014-2015 Wet Weather Monitoring Season is presented in Table 4-4.6 and Figure 4-3.6.

E. coli concentrations ranged from 17,329 to 36,540 MPN/100 mL and were above the water quality objective of 235 MPN/100 mL during all three storm events monitored for bacteria at Dominguez Channel. The highest *E. coli* concentration at Dominguez Channel was measured during 2014-15Event09. During wet weather high-flow periods, Dominguez Channel is subject to a suspension of the recreational beneficial uses. As a result of this suspension, *E. coli* concentrations above 235 MPN/100 mL are not highlighted for 2014-15Event09 and 2014-15Event10. Based on this assessment, one of the three wet weather events analyzed for bacteria (2014-15Event04) did not meet the *E. coli* water quality objective (Table 4-4.6 and Figure 4-3.6).

Dissolved oxygen concentrations ranged from 3.67 to 9.97, and one of the three values (measured during 2014-15Event04) was below the water quality objective of 5 mg/L (Table 4-4.6).

Several metals were above their corresponding hardness-based water quality objectives for at least one wet weather sample collected at Dominguez Channel (Table 4-4.6). Dissolved copper concentrations ranged from 27.8 to 172 μg/L and were above the water quality objective for all three of the wet weather samples collected at Dominguez Channel. Dissolved zinc was also above the hardness-based water quality objective for all three wet weather samples, with concentrations ranging from 142 to 880 μg/L. Dissolved lead concentrations ranged from 14.2 to 38.8 μg/L, and one of the three concentrations (measured during 2014-15Event10) was above the hardness-based water quality objective. Hardness values for samples collected during wet weather at Dominguez Channel ranged from 25 to 145 mg/L (Table 4-4.6).

All other applicable water quality objectives at the Dominguez Channel MES were met during the 2014-2015 Wet Weather Monitoring Season.

4.3.1.7 Santa Clara River (S29)

A summary of the constituents that did not meet applicable water quality objectives at the Santa Clara River MES during the 2014-2015 Wet Weather Monitoring Season is presented in Table 4-4.7 and Figure 4-3.7.

E. coli bacteria concentrations ranged from 16,000 to 61,310 MPN/100 mL and were above the applicable water quality objective of 235 MPN/100 mL during all three of the sampled storm events at Santa Clara River (Table 4-4.7 and Figure 4-3.7). The highest *E. coli* concentration at Santa Clara River was measured during 2014-15Event10. Santa Clara River is not subject to the high-flow suspension of the recreational beneficial uses.

Dissolved copper concentrations ranged from 23.2 to 85.4 μg/L and were above the hardness-based water quality objective for all three of the wet weather samples collected at Santa Clara River. Dissolved zinc concentrations were also above the hardness-based water quality objective for two of the three wet weather samples (2014-15Event04 and 2014-15Event10), with concentrations ranging from 108 to 437 μg/L. Hardness values for samples collected during wet weather at Santa Clara River ranged from 38 to 228 mg/L (Table 4-4.7).

All other applicable water quality objectives at the Santa Clara River MES were met during the 2014-2015 Wet Weather Monitoring Season.

4.3.2 Tributary Stations During Wet Weather

4.3.2.1 Upper Las Virgenes Creek (TS25)

A summary of the constituents that did not meet applicable water quality objectives at the Upper Las Virgenes Creek Tributary Station (TS25) during the 2014-2015 Wet Weather Monitoring Season is presented in Table 4-5.1 and Figure 4-4.1.

E. coli bacteria concentrations ranged from 7,400 to 44,100 MPN/100 mL and were above the applicable water quality objective of 235 MPN/100 mL during all four wet weather events monitored for bacteria (Table 4-5.1 and Figure 4-4.1). The highest *E. coli* concentration at Upper Las Virgenes Creek was measured during 2014-15Event04. Malibu Creek tributaries are not subject to a high-flow suspension of the recreational beneficial uses.

Dissolved oxygen concentrations ranged from 3.79 to 10.1, and was below the water quality objective of 5 mg/L during 2014-15Event04 (Table 4-5.1).

Dissolved copper concentrations ranged from 11.7 to 29.4 μg/L and were above the hardness-based water quality objective for one of the four wet weather samples collected at Upper Las Virgenes Creek (measured during 2014-15Event10). Dissolved zinc concentrations were also above the hardness-based water quality objective for one of the four wet weather samples (2014-15Event04), with concentrations ranging from 57.9 to 483 μg/L. Hardness values for samples collected during wet weather at Upper Las Virgenes Creek ranged from 100 to 408 mg/L (Table 4-5.1).

All other applicable water quality objectives at Upper Las Virgenes Creek were met during the 2014-2015 Wet Weather Monitoring Season.

4.3.2.2 Cheseboro Canyon (TS26)

A summary of the constituents that did not meet applicable water quality objectives at the Cheseboro Canyon Tributary Station (TS26) during the 2014-2015 Wet Weather Monitoring Season is presented in Table 4-5.2 and Figure 4-4.2.

E. coli bacteria concentrations ranged from 4,100 to 41,060 MPN/100 mL and were above the applicable water quality objective of 235 MPN/100 mL during all four wet weather events monitored for bacteria (Table 4-5.2 and Figure 4-4.2). The highest *E. coli* concentration at Cheseboro Canyon was measured during 2014-15Event10. Malibu Creek tributaries are not subject to a high-flow suspension of the recreational beneficial uses.

Dissolved oxygen concentrations ranged from 3.92 to 9.97, and two of the four values (measured during 2014-15Event04 and 2014-15Event08) were below the water quality objective of 5 mg/L (Table 4-5.2).

Dissolved copper concentrations ranged from 13.6 to 36.1 μg/L and were above the hardness-based water quality objective for three of the four wet weather samples collected at Cheseboro Canyon (measured during 2014-15Event08, 2014-15Event09, and 2014-15Event10). Dissolved zinc concentrations were also above the hardness-based water quality objective for three of the four wet weather samples (2014-15Event04, 2014-15Event08, and 2014-15Event09), with concentrations ranging from 67.7 to 745 μg/L. Hardness values for samples collected during wet weather at Cheseboro Canyon ranged from 53 to 275 mg/L (Table 4-5.2).

All other applicable water quality objectives at Cheseboro Canyon were met during the 2014-2015 Wet Weather Monitoring Season.

4.3.2.3 Lower Lindero Creek (TS27)

A summary of the constituents that did not meet applicable water quality objectives at the Lower Lindero Creek Tributary Station (TS27) during the 2014-2015 Wet Weather Monitoring Season is presented in Table 4-5.3 and Figure 4-4.3.

E. coli bacteria concentrations ranged from 2,359 to 13,330 MPN/100 mL and were above the applicable water quality objective of 235 MPN/100 mL during all four of the wet weather events monitored for bacteria (Table 4-5.3 and Figure 4-4.3). The highest *E. coli* concentration at Lower

Lindero Creek was measured during 2014-15Event10. Malibu Creek tributaries are not subject to a high-flow suspension of the recreational beneficial uses.

Dissolved oxygen concentrations ranged from 3.54 to 9.79, and one of the four values (measured during 2014-15Event04) was below the water quality objective of 5 mg/L (Table 4-5.3).

Several metals were above their corresponding hardness-based water quality objectives for at least one wet weather sample collected at Lower Lindero Creek (Table 4-5.3). Dissolved copper concentrations ranged from 17.9 to 83.9 μg/L, and two of the four concentrations (measured during 2014-15Event04 and 2014-15Event08) were above the hardness-based water quality objective. Dissolved cadmium concentrations ranged from 0.728 to 46.4 μg/L and were above the water quality objective for one of the four wet weather samples collected at Lower Lindero Creek (2014-15Event04). Dissolved zinc was also above the hardness-based water quality objective for one of four wet weather samples (2014-15Event04), with concentrations ranging from 26.5 to 645 μg/L. Hardness values for samples collected during wet weather at Lower Lindero Creek ranged from 228 to 455 mg/L (Table 4-5.3).

All other applicable water quality objectives at Lower Lindero Creek were met during the 2014-2015 Wet Weather Monitoring Season.

4.3.2.4 Medea Creek (TS28)

A summary of the constituents that did not meet applicable water quality objectives at the Medea Creek Tributary Station (TS28) during the 2014-2015 Wet Weather Monitoring Season is presented in Table 4-5.4 and Figure 4-4.4.

E. coli bacteria concentrations ranged from 4,100 to 21,870 MPN/100 mL and were above the applicable water quality objective of 235 MPN/100 mL during all four wet weather events monitored for bacteria (Table 4-5.4 and Figure 4-4.4). The highest *E. coli* concentration at Medea Creek was measured during 2014-15Event04. Malibu Creek tributaries are not subject to a suspension of the recreational beneficial uses.

Dissolved oxygen concentrations ranged from 3.57 to 9.99, and two of the four values (measured during 2014-15Event04 and 2014-15Event08) were below the water quality objective of 5 mg/L (Table 4-5.4).

The sulfate concentration was slightly above the water quality objective of 500 mg/L for one of the four monitored wet weather events (2014-15Event04). Sulfate concentrations ranged from 105 to 508 mg/L (Table 4-5.4).

Several metals were above their corresponding hardness-based water quality objectives for at least one wet weather sample collected at Medea Creek (Table 4-5.4). Dissolved copper concentrations ranged from 23.5 to 74.4 μg/L, and two of the four concentrations (measured during 2014-15Event04 and 2014-15Event10) were above the hardness-based water quality objective. Dissolved cadmium concentrations ranged from 5.47 to 26.9 μg/L and were above the water quality objective for one of the four wet weather samples collected at Medea Creek (2014-15Event04). Dissolved zinc was also above the hardness-based water quality objective for one of four wet weather samples (2014-15Event04), with concentrations ranging from 59.2 to 398 µg/L. Hardness values for samples collected during wet weather at Medea Creek ranged from 170 to 578 mg/L (Table 4-5.4).

All other applicable water quality objectives at Medea Creek were met during the 2014-2015 Wet Weather Monitoring Season.

4.3.2.5 Liberty Canyon Channel (TS29)

A summary of the constituents that did not meet applicable water quality objectives at the Liberty Canyon Channel Tributary Station (TS29) during the 2014-2015 Wet Weather Monitoring Season is presented in Table 4-5.5 and Figure 4-4.5.

E. coli bacteria concentrations ranged from 8,164 to 48,900 MPN/100 mL and were above the applicable water quality objective of 235 MPN/100 mL during all four wet weather events monitored for bacteria at Liberty Canyon Channel (Table 4-5.5 and Figure 4-4.5). The highest *E. coli* concentration at Liberty Canyon Channel was measured during 2014-15Event08. Malibu Creek tributaries are not subject to a suspension of the recreational beneficial uses.

Dissolved oxygen concentrations ranged from 4.74 to 10.0, and one of the four values (measured during 2014-15Event04) was slightly below the water quality objective of 5 mg/L (Table 4-5.5).

Dissolved copper concentrations ranged from 15.1 to 99.7 µg/L and were above the hardness-based water quality objective for three of the four wet weather samples collected at Liberty Canyon Channel (measured during 2014-15Event04, 2014-15Event09, and 2014-15Event10). Dissolved zinc concentrations were also above the hardness-based water quality objective for one of the four wet weather samples (2014-15Event04), with concentrations ranging from 62.2 to 655 µg/L. Hardness values for samples collected during wet weather at Liberty Canyon Channel ranged from 73 to 353 mg/L (Table 4-5.5).

All other applicable water quality objectives at Liberty Canyon Channel were met during the 2014-2015 Wet Weather Monitoring Season.

4.3.2.6 PD 728 at Foxfield Drive (TS30)

A summary of the constituents that did not meet applicable water quality objectives at the PD 728 at Foxfield Drive Tributary Station (TS30) during the 2014-2015 Wet Weather Monitoring Season is presented in Table 4-5.6 and Figure 4-4.6.

E. coli bacteria concentrations ranged from 6,131 to 20,100 MPN/100 mL and were above the applicable water quality objective of 235 MPN/100 mL during all four monitored wet weather events at the PD 728 at Foxfield Drive Tributary Station (Table 4-5.6 and Figure 4-4.6). The highest *E. coli* concentration at PD728 at Foxfield Drive was measured during 2014-15Event09. Malibu Creek tributaries are not subject to a suspension of the recreational beneficial uses.

Dissolved oxygen concentrations ranged from 4.1 to 10.0, and one of the four values (measured during 2014-15Event04) was below the water quality objective of 5 mg/L (Table 4-5.6).

Dissolved copper concentrations ranged from 11.5 to 53.2 μg/L and were above the hardness-based water quality objective for two of the four wet weather samples collected at PD 728 at Foxfield Drive (measured during 2014-15Event04 and 2014-15Event09). Dissolved zinc concentrations were also above the hardness-based water quality objective for one of the four wet weather samples (2014-15Event04), with concentrations ranging from 46.1 to 354 μg/L. Hardness values for samples collected during wet weather at PD 728 at Foxfield Drive ranged from 108 to 270 mg/L (Table 4-5.6).

All other applicable water quality objectives at PD 728 at Foxfield Drive were met during the 2014-2015 Wet Weather Monitoring Season.

4.3.3 Mass Emission Stations During Dry Weather

4.3.3.1 Ballona Creek (S01)

All applicable water quality objectives at the Ballona Creek MES were met during the 2014-2015 Dry Weather Monitoring Season (Table 4-4.1).

4.3.3.2 Malibu Creek (S02)

A summary of constituents that did not meet applicable water quality objectives at the Malibu Creek MES during the 2014-2015 Dry Weather Monitoring Season is presented in Table 4-4.2 and Figure 4-5.2.

Sulfate concentrations ranged from 527 to 531. Both values were slightly above the water quality objective of 500 mg/L (Table 4-4.2).

All other applicable water quality objectives at the Malibu Creek MES were met during the 2014-2015 Dry Weather Monitoring Season.

4.3.3.3 Los Angeles River (S10)

A summary of constituents that did not meet applicable water quality objectives at the Los Angeles River MES during the 2014-2015 Dry Weather Monitoring Season is presented in Table 4-4.3 and Figure 4-5.3.

E. coli bacteria concentrations ranged from 100 to 288 MPN/100 mL. One of the two values (measured during the second event, 2014-15Event18) was slightly above the applicable water quality objective of 235 MPN/100 mL (Table 4-4.3).

pH values ranged from 9.29 to 9.48 and were above the upper limit of the water quality objective range of 6.5–8.5 pH units for both dry weather samples (Table 4-4.3).

All other applicable water quality objectives in the Los Angeles River MES were met during the 2014-2015 Dry Weather Monitoring Season.

4.3.3.4 Coyote Creek (S13)

A summary of constituents that did not meet applicable water quality objectives at the Coyote Creek MES during the 2014-2015 Dry Weather Monitoring Season is presented in Table 4-4.4 and Figure 4-5.4.

E. coli bacteria concentrations ranged from 305 to 546 MPN/100 mL and were above the applicable water quality objective of 235 MPN/100 mL during both events (Table 4-4.4). The highest *E. coli* concentration at Coyote Creek was measured during 2014-15Event18.

pH values ranged from 8.55 to 8.77 and were slightly above the upper limit of the water quality objective range of 6.5-8.5 pH units for both dry weather samples (Table 4-4.4).

All other applicable water quality objectives at Coyote Creek were met during the 2014-2015 Dry Weather Monitoring Season.

4.3.3.5 San Gabriel River (S14)

One dry weather event (2014-15Event18) was sampled at San Gabriel River MES during the 2014-2015 Dry Weather Monitoring Season due to lack of flow during the first dry weather event (2014-15Event 13). All applicable water quality objectives at the San Gabriel River MES were met during the 2014-2015 Dry Weather Monitoring Season (Table 4-4.5).

4.3.3.6 Dominguez Channel (S28)

A summary of constituents that did not meet applicable water quality objectives at the Dominguez Channel MES during the 2014-2015 Dry Weather Monitoring Season is presented in Table 4-4.6 and Figure 4-5.6.

E. coli bacteria concentrations ranged from 63 to 520 MPN/100 mL, and one of the two values (2014-15Event16) was above the applicable water quality objective of 235 MPN/100 mL (Table 4-4.6). The highest *E. coli* concentration at Dominguez Channel was measured during 2014-15Event16.

pH values ranged from 8.51 to 8.63 and were slightly above the water quality objective range of 6.5–8.5 pH units for both dry weather samples (Table 4-4.6).

All other applicable water quality objectives at Dominguez Channel were met during the 2014-2015 Dry Weather Monitoring Season.

4.3.3.7 Santa Clara River (S29)

All applicable water quality objectives at the Santa Clara River MES were met during the 2014-2015 Dry Weather Monitoring Season (Table 4-4.7).

4.3.4 Tributary Stations During Dry Weather

4.3.4.1 Upper Las Virgenes Creek (TS25)

A summary of the constituents that did not meet applicable water quality objectives at Upper Las Virgenes Creek (TS25) during the 2014-2015 Dry Weather Monitoring Season is presented in Table 4-5.1 and Figure 4-6.1.

E. coli bacteria concentrations ranged from 79.4 to 1,000, and one of the two values (measured during 2014-15Event18) was above the applicable water quality objective of 235 MPN/100 mL (Table 4-5.1 and Figure 4-6.1).

Sulfate concentrations ranged from 1,130 to 1,410 mg/L and were above the water quality objective of 500 mg/L for both of the dry weather events at Upper Las Virgenes Creek (Table 4-5.1).

Concentrations of TDS ranged from 2,430 to 2,890 mg/L and were above the water quality objective of 2,000 mg/L during both monitored dry weather events at Upper Las Virgenes Creek (Table 4-5.1).

All other applicable water quality objectives in Upper Las Virgenes Creek were met during the 2014-2015 Dry Weather Monitoring Season.

4.3.4.2 Cheseboro Canyon (TS26)

A summary of the constituents that did not meet applicable water quality objectives at the Cheseboro Canyon Tributary Station (TS26) during the 2014-2015 Dry Weather Monitoring Season is presented in Table 4-5.2 and Figure 4-6.2.

Sulfate concentrations ranged from 1,190 to 1,330 mg/L and were above the water quality objective of 500 mg/L for both of the dry weather events at Cheseboro Canyon (Table 4-5.2).

Concentrations of TDS ranged from 2,620 to 2,710 mg/L and were above the water quality objective of 2,000 mg/L during both monitored dry weather events at Cheseboro Canyon (Table 4-5.2).

All other applicable water quality objectives in Cheseboro Canyon were met during the 2014-2015 Dry Weather Monitoring Season.

4.3.4.3 Lower Lindero Creek (TS27)

A summary of the constituents that did not meet applicable water quality objectives at the Lower Lindero Creek Tributary Station (TS27) during the 2014-2015 Dry Weather Monitoring Season is presented in Table 4-5.3 and Figure 4-6.3. Three dry weather samples were collected at the Lower Lindero Creek station during 2014-2015 dry weather monitoring. An extra dry weather monitoring event was conducted January 15, 2015 in anticipation of a construction project that may have impacted the ability to sample the station.

E. coli bacteria concentrations ranged from 100 to 630 MPN/100 mL, and one of the three values (measured during the third event, 2014-15Event18) was above the applicable water quality objective of 235 MPN/100 mL (Table 4-5.3 and Figure 4-6.3).

Sulfate concentrations ranged from 604 to 762 mg/L and were above the water quality objective of 500 mg/L for all three dry weather events at Lower Lindero Creek (Table 4-5.3).

All other applicable water quality objectives in Lower Lindero Creek were met during the 2014-2015 Dry Weather Monitoring Season.

4.3.4.4 Medea Creek (TS28)

A summary of the constituents that did not meet applicable water quality objectives at the Medea Creek Tributary Station (TS28) during the 2014-2015 Dry Weather Monitoring Season is presented in Table 4-5.4 and Figure 4-6.4.

The sulfate concentration measured during both dry weather events at Medea Creek was 1,250 mg/L, which is above the water quality objective of 500 mg/L (Table 4-5.4).

Concentrations of TDS ranged from 2,680 to 2,820 and were above the water quality objective of 2,000 mg/L for both of the dry weather events at Medea Creek (Table 4-5.4).

All other applicable water quality objectives in Medea Creek were met during the 2014-2015 Dry Weather Monitoring Season.

4.3.4.5 Liberty Canyon Channel (TS29)

A summary of the constituents that did not meet applicable water quality objectives at the Liberty Canyon Channel Tributary Station (TS29) during the 2014-2015 Dry Weather Monitoring Season is presented in Table 4-5.5 and Figure 4-6.5.

E. coli bacteria concentrations ranged from 98 to 410 MPN/100 mL, and one of the two values (measured during the second event, 2014-15Event18) was above the applicable water quality objective of 235 MPN/100 mL (Table 4-5.5 and Figure 4-6.5).

Sulfate concentrations ranged from 654 to 859 mg/L and were above the water quality objective of 500 mg/L for both dry weather events at Liberty Canyon Channel (Table 4-5.5).

All other applicable water quality objectives in Liberty Canyon Channel were met during the 2014-2015 Dry Weather Monitoring Season.

4.3.4.6 PD 728 at Foxfield Drive (TS30)

A summary of constituents that did not meet applicable water quality objectives at the PD 728 at Foxfield Drive Tributary Station (TS30) during the 2014-2015 Dry Weather Monitoring Season is presented in Table 4-5.6 and Figure 4-6.6.

E. coli bacteria concentrations ranged from 175 to 1,750 MPN/100 mL, and one of the two values (measured during the first event, 2014-15Event13) was above the applicable water quality objective of 235 MPN/100 mL (Table 4-5.6 and Figure 4-6.6).

Sulfate concentrations ranged from 619 to 636 mg/L and were above the water quality objective of 500 mg/L during both of the dry weather events at PD 728 at Foxfield Drive (Table 4-5.6).

All other applicable water quality objectives in PD 728 at Foxfield Drive were met during the 2014-2015 Dry Weather Monitoring Season.

4.3.5 Summary of Constituents That Did Not Meet Water Quality Objectives

A summary of the constituents that did not meet applicable water quality objectives at the MES and tributary stations is presented in the following subsections.

4.3.5.1 Mass Emission Stations

This subsection and the table that follows summarize the constituents that did not meet water quality objectives at the MES monitoring stations during the 2014–2015 Monitoring Season.

During wet weather, indicator bacteria did not meet water quality objectives during at least one event at all seven MES. Following the application of the high-flow suspension of *E. coli* water quality objectives (where appropriate), *E. coli* concentrations were above the water quality objective during one of three wet weather events at Ballona Creek, Los Angeles River, Coyote Creek, and Dominguez Channel; during two of three events at Malibu Creek, and during all three events at Santa Clara River. The high-flow suspension does not apply at the Malibu Creek and Santa Clara River MES.

At the MES located in urbanized watersheds (i.e., Ballona Creek, Los Angeles River, and Dominguez Channel) and at the Coyote Creek MES, dissolved copper and dissolved zinc did not meet water quality objectives during all three wet weather events. Additional metals that did not meet water quality objectives included dissolved copper during one of three events at San Gabriel River and all three events at Santa Clara River; dissolved zinc during two of three events at Santa Clara River; and dissolved lead during two of three events at Ballona Creek, and one of three events at Los Angeles River and Dominguez Channel.

pH, dissolved oxygen, nitrite as N, sulfate, and cyanide also did not meet water quality objectives at one or more MES locations during wet weather. pH was slightly above the upper limit of the water quality objective range during one of three events at Ballona Creek. Nitrite as N did not meet the water quality objective during one of three events at Ballona Creek and Los Angeles River. Sulfate did not meet the water quality objective during one of three events at Malibu Creek. Cyanide did not meet the water quality objective during one of three wet weather events at San Gabriel River. Dissolved oxygen was measured below the water quality objective during 2014-15Event04 at Ballona Creek, Los Angeles River, Coyote Creek, San Gabriel River, and Dominguez Channel.

During dry weather conditions, pH and *E. coli* were the analytes that most frequently did not meet water quality objectives. pH values were above the upper limit of the water quality objective range during both events at Los Angeles River, Coyote Creek, and Dominguez Channel. *E. coli* did not meet water quality objectives during both dry weather events at the Coyote Creek MES and one event at the Los Angeles River and Dominguez Channel MES. Sulfate also did not meet water quality objectives at the Malibu Creek MES location during both dry weather events; both values were slightly above the water quality objective.

Summary of Constituents that Did Not Meet Water Quality Objectives at Mass Emission Stations during 2014-2015 for One or More Events

Mass Emission Station/Watershed	Wet	Dry
Ballona Creek (S01)[1,2,3]	*E. coli* Dissolved copper Dissolved zinc Dissolved lead Nitrite as N Dissolved oxygen pH	NA
Malibu Creek (S02)	*E. coli* Sulfate	Sulfate
Los Angeles River (S10)[1,2,3]	*E. coli* Dissolved copper Dissolved zinc Dissolved lead Nitrite as N Dissolved oxygen	*E. coli* pH
Coyote Creek (S13)[2,3]	*E. coli* Dissolved copper Dissolved zinc Dissolved oxygen	*E. coli* pH
San Gabriel River (S14)[2,]	Dissolved copper Cyanide Dissolved oxygen	NA
Dominguez Channel (S28)[1,2,3]	*E. coli* Dissolved copper Dissolved zinc Dissolved lead Dissolved oxygen	*E. coli* pH
Santa Clara River (S29)	*E. coli* Dissolved copper Dissolved zinc	NA

NA – all applicable water quality objectives were met.
[1]More urbanized watersheds.
[2]Subject to the bacteria water quality objective high-flow suspension (LARWQCB, 2003).
[3]The high flow suspension did not apply to Ballona Creek, Los Angeles River, Coyote Creek, and Dominguez Channel during 2014-15Event04.

4.3.5.2 Tributary Monitoring Stations

This subsection and the table that follows summarize the constituents that did not meet water quality objectives at the tributary monitoring stations during the 2014–2015 Monitoring Season.

During wet weather, *E. coli* concentrations did not meet the water quality objective during all monitored events at all six tributary stations. In addition, dissolved copper, and dissolved zinc did not meet the hardness-based water quality objective during at least one wet weather event at all six tributary stations. Dissolved oxygen also did not meet the water quality objective during at least one wet weather event at all six tributary stations. Dissolved cadmium did not meet the hardness-based water quality objective during one event each at the Lower Lindero Creek and Medea Creek tributary stations.

The only other analyte that did not meet water quality objectives during wet weather was sulfate, which was measured at a concentration slightly above the water quality objective during one of four wet weather events at Medea Creek. There was also a sulfate exceedance during wet weather at the Malibu Creek MES.

During dry weather, sulfate did not meet water quality objectives during both monitored events at all six tributary stations. Sulfate also exceeded the water quality objective during both dry weather events at the Malibu Creek MES.

In addition, *E. coli* and TDS frequently did not meet water quality objectives during dry weather monitoring at the tributary stations. *E. coli* was above the water quality objective during one of two dry weather events at Upper Las Virgenes Creek, Liberty Canyon Channel, and PD28 at Foxfield Drive and during one of three events at Lower Lindero Creek. TDS was above the water quality objective during both monitored dry weather events at the Upper Las Virgenes Creek, Cheseboro Canyon, and Medea Creek tributary stations. *E. coli* and TDS met water quality objectives during both dry weather events at the Malibu Creek MES.

Summary of Constituents That Did Not Meet Water Quality Objectives at Tributary Stations during 2014-2015 for One or More Events

Tributary/Sub-Watershed	Wet	Dry
Upper Las Virgenes Creek (TS25)	*E. coli* Dissolved copper Dissolved zinc Dissolved oxygen	*E. coli* Sulfate TDS
Cheseboro Canyon (TS26)	*E. coli* Dissolved copper Dissolved zinc Dissolved oxygen	Sulfate TDS
Lower Lindero Creek (TS27)	*E. coli* Dissolved copper Dissolved zinc Dissolved cadmium Dissolved oxygen	*E. coli* Sulfate
Medea Creek (TS28)	*E. coli* Dissolved copper Dissolved zinc Dissolved cadmium Sulfate Dissolved oxygen	Sulfate TDS
Liberty Canyon Channel (TS29)	*E. coli* Dissolved copper Dissolved zinc Dissolved oxygen	*E. coli* Sulfate
PD 728 at Foxfield Dr. (TS30)	*E. coli* Dissolved copper Dissolved zinc Dissolved oxygen	*E. coli* Sulfate

TDS – total dissolved solids.

4.3.6 Water Column Toxicity Analysis

Water column toxicity monitoring was performed at all MES. In total, four samples were analyzed for toxicity at each station (i.e., two wet weather samples and two dry weather samples). The only exception was San Gabriel River (S14), where only one dry weather sample was collected due to the absence of flow during the first dry weather monitoring event. Wet weather samples were collected during the first rain event of the season on November 1-3, 2014 (2014–15Event04) for each of the MES locations except S02, which was collected on December 1, 2014 (2014-15Event08). The second wet weather samples were collected on December 2-4, 2014 (2014–15Event09) for each of the MES locations. The first dry weather samples were collected on January 8, 2015 (2014–15Event13) for each of the MES locations except S28, which was collected on January 22, 2015 (2014–15Event16), and San Gabriel River (S14) due to dry conditions (no flow). The second dry weather samples were collected on February 11-12, 2015 (2014-15Event18) for each of the MES locations. The toxicity results from these samples are summarized in Table 4-10a (dry weather) and Table 4-10b (wet weather).

One freshwater species (water flea) and one marine species (sea urchin) were used for toxicity testing. The water flea, *Ceriodaphnia dubia*, was used in chronic 7-day reproduction and survival bioassays. The sea urchin, *Strongylocentrotus purpuratus*, was used in chronic fertilization bioassays.

4.3.6.1 Toxicity Results – Wet Weather

Bioassay tests exposing *C. dubia* to wet weather effluent samples from each of the seven MES indicated that no toxicity to *C. dubia* survival or reproduction was observed for both events. All of the IC_{25} and IC_{50} values were greater than 100%, the NOEC values were 100%, and the TUs (100/ $IC_{50)}$ were calculated as < 1.

Toxicity tests measuring *S. purpuratus* fertilization in exposures to wet weather effluent samples from all seven MES indicated that no toxicity to *S. purpuratus* fertilization was observed in the test samples. All of the NOEC values were 100%, IC_{25} and IC_{50} values were greater than 100%, and the TUs were calculated as < 1.

4.3.6.2 Toxicity Results – Dry Weather

Bioassay tests exposing *C. dubia* to dry weather effluent samples from each MES indicated that no toxicity to *C. dubia* survival or reproduction was observed for both events. All of the IC_{25} and IC_{50} values were greater than 100%, the NOEC values were 100%, and the TUs were calculated as < 1.

Toxicity tests measuring *S. purpuratus* fertilization in exposures to dry weather effluent samples from each MES indicated that no toxicity to *S. purpuratus* fertilization was observed in the test samples. All of the IC_{25} and IC_{50} values were greater than 100% test substance, the NOEC values were 100%, and the TUs were < 1.

4.3.7 Trash Monitoring Analysis

In accordance with the 2001 Monitoring and Reporting Program, visual observations of trash were made and at least one photograph was taken at each MES after the first storm event and after at least three additional storm events during the 2014-2015 monitoring season. The only exception was the Santa Clara River MES, the only MES that is not automated and does not require TSS sampling after three storm events are monitored. At this station, photographs were taken during the first storm event and two additional storm events. Per the Monitoring and Reporting Program, four trash surveys are required at all stations, include the Santa Clara MES. Photographs are presented in Appendix C. Ballona Creek Watershed and Los Angeles River Watershed Trash Compliance Monitoring Reports are presented in Appendices I and J, respectively.

4.4 2014-2015 Data Analyses

Data analyses completed for the 2014-2015 monitoring season include evaluations of TSS correlations, watershed constituent loads, and trends. Results of these analyses are discussed in the following subsections.

4.4.1 Correlations to Total Suspended Solids

A Spearman's Rank Test was used to determine whether a significant positive or negative correlation existed between analytical chemistry results and TSS concentrations at each MES and tributary station during wet weather conditions. The TSS concentrations from composite samples collected during wet weather events are summarized in Table 4-6. Other constituents analyzed that had significant correlations to TSS are detailed in Table 4-7 and discussed below. Scatter plots of selected constituents that had significant correlations with TSS are presented in Figure 4-7.

Spearman's Rank Test is a rank-based correlation that uses the ranks of the data instead of the actual sample results. This non-parametric test is employed when the data are not normally distributed. The ranks of each data set to be correlated are ordered from highest to lowest, with the highest number in each set given a rank of "1" and so on to the lowest value in each data set. The Spearman rank correlation coefficient, r_s, is then calculated using the ranks and compared to the critical r_s value. The critical r_s value is based on the number of samples and the required alpha (0.05 for this analysis). If the r_s is greater than the critical r_s, then the correlation is considered "significant," or the result has a less than 5% chance of occurring randomly (there is a 95% confidence that this result did not occur by chance).

Many constituents have a strong binding affinity for sediment particles in stormwater effluent; particularly bacteria, metals, organics, and total organic carbon (TOC). It is important to note that the correlations discussed below were based on a small data set and may not be representative of actual conditions during a storm.

4.4.1.1 Wet Weather – Mass Emission Stations

Due to the small sample size (n=3) at all MES stations during the 2014-2015 Wet Weather Monitoring Season, all correlations at the MES are discussed as likely correlations; results should be considered in the context of the small sample size. The results of the correlation analyses are summarized in the table below.

Only a few relationships were observed while evaluating correlations between TSS and priority constituents (those constituents that did not meet water quality objectives in one or more monitoring events) across MES during wet weather. Priority constituents evaluated for relationships with TSS included *E. coli*, dissolved metals (copper, zinc, and lead), nitrite as N, and dissolved oxygen at Ballona Creek; *E. coli* and sulfate at Malibu Creek; *E coli*, dissolved metals (copper, zinc, and lead), nitrite as N, and dissolved oxygen at Los Angeles River; *E. coli*, dissolved metals (copper and zinc), and dissolved oxygen at Coyote Creek; dissolved copper, cyanide, and dissolved oxygen at San Gabriel River; *E. coli*, dissolved metals (copper, zinc, and lead), and dissolved oxygen at Dominguez Channel; and *E. coli* and dissolved metals (copper and zinc) at Santa Clara River.

The only likely positive correlations of TSS to priority constituents were *E. coli*, dissolved copper, dissolved lead, and dissolved zinc at Ballona Creek and dissolved copper and dissolved lead at Los Angeles River. The only likely negative correlations to priority constituents were DO and pH at Ballona Creek, and *E. coli* at Dominguez Channel.

At Ballona Creek, several constituents were likely positively correlated with TSS. These constituents included *E. coli* (a priority constituent), alkalinity, total phosphorus, turbidity, volatile suspended solids (VSS), dissolved aluminum, dissolved arsenic, dissolved barium, dissolved cadmium, dissolved chromium, dissolved copper (a priority constituent), dissolved iron, dissolved lead (a priority constituent), dissolved nickel, dissolved zinc (a priority constituent), aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, nickel, silver, and zinc. Likely negative correlations to TSS at Ballona Creek included total coliform, DO (a priority constituent), pH (a priority constituent), nitrate, and nitrate as N.

At Malibu Creek, the only likely positive correlation to TSS was VSS and likely negative correlations included chloride, dissolved barium, and aluminum.

Likely positive correlations to TSS at Los Angeles River included fecal coliform, cyanide, Kjeldahl N, turbidity, VSS, dissolved barium, dissolved cadmium, dissolved chromium, dissolved copper (a priority constituent), dissolved iron, dissolved lead (a priority constituent), dissolved nickel, arsenic, barium, cadmium, iron, lead, and silver. The only likely negative correlation to TSS was pH.

At Coyote Creek, likely positive correlations to TSS included Fecal coliform, alkalinity, hardness, Kjeldahl N, turbidity, and VSS. No likely negative correlations were observed.

Likely positive correlations to TSS at San Gabriel River included pH, turbidity, and VSS, and likely negative correlations included total coliform, biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved phosphorus, dissolved nickel, antimony, and zinc.

At Dominguez Channel, likely positive correlations included Kjeldahl N, turbidity, and VSS. Likely negative correlations to TSS included *E. coli* (a priority constituent), fecal coliform, fecal enterococcus, fecal streptococcus, and pH.

At Santa Clara River, likely positive correlations to TSS included BOD, dissolved phosphorus, total phosphorus, VSS, arsenic, barium, cadmium, chromium, iron, nickel, and silver. Likely negative correlations included fecal coliform and pH.

Likely Correlations Between Constituents and Total Suspended Solids at Mass Emission Stations

Mass Emission/Watershed	Wet	
	Positively Correlated with TSS	Negatively Correlated with TSS
Ballona Creek (S01) [1]	*E. coli**, alkalinity, total phosphorus, turbidity, VSS, dissolved aluminum, dissolved arsenic, dissolved barium, dissolved cadmium, dissolved chromium, dissolved copper*, dissolved iron, dissolved lead*, dissolved nickel, dissolved zinc*, aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, nickel, silver, zinc	Total coliform, DO*, pH*, nitrate-NO_3, nitrate-N
Malibu Creek (S02) [1]	VSS	Chloride, dissolved barium, aluminum
Los Angeles River (S10) [1]	Fecal coliform, cyanide, Kjeldahl N, turbidity, VSS, dissolved barium, dissolved cadmium, dissolved chromium, dissolved copper*, dissolved iron, dissolved lead*, dissolved nickel, arsenic, barium, cadmium, iron, lead, silver	pH
Coyote Creek (S13) [1]	Fecal coliform, alkalinity, hardness, Kjeldahl N, turbidity, VSS	None
San Gabriel River (S14) [1]	pH, Turbidity, VSS	Total coliform, BOD, COD, dissolved phosphorus, dissolved nickel, antimony, zinc
Dominguez Channel (S28) [1]	Kjeldahl N, turbidity, VSS	*E. coli**, fecal coliform, fecal enterococcus, fecal streptococcus, pH
Santa Clara River (S29) [1]	BOD, dissolved phosphorus, total phosphorus, VSS, arsenic, barium, cadmium, chromium, iron, nickel, silver	Fecal coliform, pH

* Priority constituent
[1] Likely correlations; too few wet weather events for confirmation
DO = dissolved oxygen
VSS = volatile suspended solids
BOD = biochemical oxygen demand
COD = chemical oxygen demand

4.4.1.2 Wet Weather – Tributary Stations

The results of the TSS correlation analyses at the tributary stations are summarized in the table below.

Priority constituents evaluated for relationships with TSS included *E. coli*, dissolved metals (copper and zinc), and dissolved oxygen at Upper Las Virgenes Creek; *E. coli*, dissolved metals (copper and zinc) and dissolved oxygen at Cheseboro Canyon; *E coli*, dissolved metals (copper, zinc, and cadmium), and dissolved oxygen at Lower Lindero Creek; *E. coli*, dissolved metals (copper, zinc, and cadmium), sulfate, and dissolved oxygen at Medea Creek; *E. coli*, dissolved metals (copper and zinc), and dissolved oxygen at Liberty Canyon Channel; and *E. coli*, dissolved metals (copper and zinc), and dissolved oxygen at PD728 at Foxfield Drive. There were no positive correlations of TSS to priority constituents, and the only negative correlation of TSS to a priority constituent was dissolved oxygen at PD728 at Foxfield Drive.

At Upper Las Virgenes Creek, several constituents were positively correlated with TSS. These constituents included total phosphorus, VSS, dissolved aluminum, dissolved barium, dissolved cadmium, dissolved iron, dissolved lead, aluminum, arsenic, barium, cadmium, iron, and lead. No negative correlations to TSS were observed.

At Cheseboro Canyon, the only positive correlation to TSS was VSS, and no negative correlations were observed.

Positive correlations to TSS at Lower Lindero Creek included Kjeldahl N, nitrate, nitrate as N, arsenic, and iron. No negative correlations were observed.

At Medea Creek, positive correlations to TSS included Kjeldahl N, VSS, dissolved aluminum, dissolved arsenic, dissolved iron, dissolved lead, aluminum, arsenic, chromium, and iron. No negative correlations were observed.

Positive correlations to TSS at Liberty Canyon Channel included dissolved aluminum, dissolved cadmium, dissolved chromium, and dissolved iron. No negative correlations were observed.

At PD728 at Foxfield Drive, positive correlations included BOD, chloride, hardness, total phosphorus, VSS, dissolved aluminum, dissolved cadmium, dissolved chromium, and dissolved iron. Negative correlations included dissolved oxygen (a priority constituent) and pH.

Correlations Between Constituents and Total Suspended Solids at Tributary Stations

Mass Emission/Watershed	Wet	
	Positively Correlated with TSS	Negatively Correlated with TSS
Upper Las Virgenes Creek (TS25)	Total phosphorus, VSS, dissolved aluminum, dissolved barium, dissolved cadmium, dissolved iron, dissolved lead, aluminum, arsenic, barium, cadmium, iron, lead	None
Cheseboro Canyon (TS26)	VSS	None
Lower Lindero Creek (TS27)	Kjeldahl N, nitrate-NO_3, nitrate-N, arsenic, iron	None
Medea Creek (TS28)	Kjeldahl N, VSS, dissolved aluminum, dissolved arsenic, dissolved iron, dissolved lead, aluminum, arsenic, chromium, iron	None
Liberty Canyon Channel (TS29)	Dissolved aluminum, dissolved cadmium, dissolved chromium, dissolved iron	None
PD 728 at Foxfield Dr. (TS30)	BOD, chloride, hardness, total phosphorus, VSS, dissolved aluminum, dissolved cadmium, dissolved chromium, dissolved iron	DO*, pH

* Priority constituent
DO = dissolved oxygen
VSS = volatile suspended solids
BOD = biochemical oxygen demand

4.4.2 Watershed Load Analysis

Constituent loads at each MES and tributary station were calculated for storm events that occurred during the 2014-2015 Wet Weather Monitoring Season. An estimate of the total constituent loads for each station is shown in Table 4-9. TSS loads were also calculated for storm events of at least 0.25 inch of total rainfall at all MES equipped with automated samplers. The TSS concentration for each event is shown in Table 4-6 and depicted in Figures 4-9 through 4-12. The total TSS loads for each MES is shown in Table 4-8.

Sample loads were calculated using the following equation:

$$concentration\ x\ volume\ x\ conversion\ factor\ = load$$

The sample concentration was multiplied by the volume of water sampled for each event, or in the case of the dry weather monitoring, the base flow for a 24-hour period in January (2014-15Event13 or 2014-15Event16) and February (2014-15Event18) at all stations except San

Gabriel River, which was only monitored in February due to dry conditions during the first dry weather monitoring event. Volumes used in the calculation are included in Table 4-1.

For discussion purposes, a limited constituent list comprised of *E. coli*, nitrate, total phosphorus, total petroleum hydrocarbons (TPHs), total Kjeldahl nitrogen (TKN), TDS, TSS, dissolved chromium, copper, and zinc is discussed for each MES. These constituents were chosen because of their prevalence in stormwater runoff. Loads for other analyzed constituents and for tributary stations are presented in Table 4-9.

4.4.2.1 Wet Weather and Dry Weather Constituent Loads for Each Mass Emission Station

Constituent loads were calculated to determine whether there was a relationship between storm event size and the total load for a given constituent. Calculated loads varied between stations and storm events. First-flush loading signatures (i.e., higher loads during the first monitored storm of the season than would be expected based on rainfall totals) were observed for at least one constituent at three of the seven MES locations: Ballona Creek, Malibu Creek, and Dominguez Channel. No first-flush loading signature was observed at the Los Angeles River, Coyote Creek, San Gabriel River, or Santa Clara River MES. Generally, rainfall totals were similar during 2014-15Event09 and 2014-15Event10 (1.06 to 3.00 inches) and were higher than the totals that were observed during 2014-15Event04 (the first monitored event at all MES except Malibu Creek; 0.25 to 0.75 inches) and 2014-15Event08 (the first monitored event at the Malibu Creek MES; 0.98 inches). Many constituent loads were highest during one of those two events, as discussed in the following subsections.

Dry weather loads were calculated for 2014-15Event13 (January 5, 2015) and 2014-15Event18 (February 9, 2015) at each MES except Dominguez Channel MES, where dry weather loads were calculated for 2014-15Event16 (January 22, 2015) and 2014-15Event18; and at San Gabriel River MES where monitoring did not occur during 2014-15Event13 due to dry conditions. During dry weather, constituent loads varied between stations and between sampling events. Loads were generally greater during the first event at the Dominguez Channel and Santa Clara River MES, and during the second event at the Ballona Creek, Malibu Creek, Los Angeles River, and Coyote Creek MES. Variability was generally low (1-3 times), but higher variability was observed in some cases for *E. coli*, TSS, dissolved chromium, and total phosphorus loads.

Overall, constituent loads were highest at the Los Angeles River MES and lowest at the Santa Clara River MES.

Ballona Creek (S01)

The wet weather event with the highest rainfall total at the Ballona Creek MES was 2014-15Event10 (1.33 inches). Rainfall totals for the other two wet weather events monitored at the Ballona Creek MES were 0.37 inches during 2014-15Event04 and 1.06 inches during 2014-15Event09. For each of the constituents except TKN and TDS, loads were highest during 2014-15Event10, which had the highest rainfall total and the highest intensity of the three storms monitored at the Ballona Creek MES. The load for TKN was highest during the first event, 2014-15Event04, indicating a first-flush loading signature, and the load for TDS was highest during the second event (2014-15Event09).

Dry weather loads at Ballona Creek were higher during the first event (2014–15Event13) than the second event (2014-15Event18) for total phosphorus, TSS, and dissolved chromium, and were higher during the second event for *E. coli*, TKN, nitrate, TDS, TPH, dissolved copper, and dissolved zinc. Variability was low (higher loads were only 1.1 to 3.4 times the lower loads).

Malibu Creek (S02)

The wet weather event with the highest rainfall total at the Malibu Creek MES was 2014-15Event09 (2.07 inches). The rainfall totals for the other two wet weather events monitored at the Malibu Creek MES were 0.98 inches during 2014-15Event08 and 1.64 inches during 2014-15Event10. For each of the constituents evaluated except *E. coli*, loads were highest during 2014-15Event10, which had the highest intensity of the three storms monitored at the Malibu Creek MES. The load for *E. coli* was highest during the first event, 2014-15Event08, which was the event with the lowest rainfall total. This indicates a first-flush loading signature for *E. coli*.

Dry weather loads at Malibu Creek were higher during the second event (2014-15Event18) than the first event (2014-15Event13) for each of the constituents evaluated except nitrate. Loads did not vary greatly between the two events. The highest variability was observed for dissolved copper, which was 5.5 times higher during the second event.

Los Angeles River (S10)

The highest rainfall total at the Los Angeles River MES occurred during 2014-15Event09 (1.65 inches). The rainfall totals for the other two wet weather events monitored at the Los Angeles River MES were 0.25 inches during 2014-15Event04 and 1.1 inches during 2014-15Event10. The intensity during 2014-15Event10 (0.226 inches per hour) was much higher than that during the other two events (0.031 to 0.042 inches per hour). For each constituent analyzed, the highest loads were observed either during 2014-15Event09 or 2014-15Event10. First-flush loading signatures were not observed for any of the assessed constituents.

Dry weather loads for nitrate, TSS, and dissolved chromium were higher during the first event (2014-15Event13) than the second event (2014-15Event18), whereas the loads for *E. coli*, total phosphorus, TDS, TPH, dissolved copper, and dissolved zinc were higher during the second event. Load variability was relatively low (up to 3.3 times) between the two dry weather events.

Coyote Creek (S13)

At the Coyote Creek MES, the rainfall total was highest during 2014-15Event09 (1.72 inches). The rainfall totals for the other two wet weather events monitored at the Coyote Creek MES were 0.35 inches during 2014-15Event04 and 1.32 inches during 2014-15Event10. Intensities were similar for the three storm events (0.044 to 0.049 inches per hour). For each constituent analyzed, the highest loads were observed either during 2014-15Event09 or 2014-15Event10. First-flush loading signatures were not observed for any of the assessed constituents.

Dry weather loads for nitrate, TSS, and dissolved chromium were higher during the first dry event (2014-15Event13) compared to the second dry event (2014-15Event18), and loads for E. coli, TKN, total phosphorus, TDS, TPH, dissolved copper, and dissolved zinc were higher during the second event at Coyote Creek. Load variability was generally low (less than three times) between the two dry weather events with the exception of the total phosphorus load, which was 29.5 times greater during the second event.

San Gabriel River (S14)

The highest rainfall total at the San Gabriel River MES occurred during 2014-15Event10 (1.99 inches). The rainfall totals for the other two wet weather events monitored at the San Gabriel River MES ranged from 0.75 during the first event, 2014-15Event04, to 1.8 inches during 2014-15Event09. The intensity was much higher during 2014-15Event10 (0.221 inches per hour) than during the other two events (0.053 to 0.094 inches per hour). For each constituent analyzed, the highest loads were observed either during 2014-15Event09 or 2014-15Event10. First-flush loading signatures were not observed for any of the assessed constituents.

Flow was only observed during one dry weather event (2014-15Event18) at San Gabriel River MES since there was no storm runoff during the first dry weather event (2014-15Event 13).

Dominguez Channel (S28)

The rainfall total at the Dominguez Channel MES was highest during 2014-15Event09 (2.12 inches). Rainfall totals for the other two monitored wet weather events at the Dominguez Channel MES were 0.37 inches during 2014-15Event05 and 1.19 inches during 2014-15Event10. Intensities were similar (0.038 to 0.048 inches per hour) for each event. Loads for *E. coli*, TKN, total phosphorus, TPH, TSS, and dissolved chromium were highest during 2014-15Event10 and the highest loads for TDS and dissolved zinc were observed during 2014-15Event09. The nitrate and dissolved copper loads were highest during 2014-15Event04, indicating a first-flush loading signature for these constituent. Loads for TDS and dissolved zinc during the first event were just below the highest observed loads at Dominguez Channel for those constituents, which is also indicative of first-flush loading signatures.

Dry weather loads for *E. coli*, nitrate, total phosphorus, TDS, TPH, dissolved chromium, and dissolved copper were higher during the first event at the Dominguez Channel MES (2014-15Event16), while loads for TKN, TSS, and dissolved zinc were higher during the second event (2014-15Event18). Loads did not vary greatly (less than two times) with the exceptions of *E. coli*, TSS, and dissolved chromium, which varied by 11.2 to 13.2 times.

Santa Clara River (S29)

The rainfall totals during 2014-15Event09 (3.0 inches) and 2014-15Event10 (2.77 inches) at the Santa Clara River MES were similar and were much higher than the rainfall total during the first monitored wet weather event, 2014-15Event04 (0.51 inches). The rainfall intensity was much higher during 2014-2015Event10 than the other events, and loads for each constituent evaluated were also greatest during that event. Even though the rainfall total during the first event, 2014-15Event04, was much lower than during the other two events, the second-highest load for each constituent was observed during this event. This is indicative of first-flush loading signatures.

Dry weather loads for all constituents evaluated for this analysis were greater during the first event (2014-15Event13) than the second (2014-15Event18) at the Santa Clara River MES. Load variability was generally low (less than 3 times) between the two dry weather events with the exceptions of the *E. coli*, dissolved chromium, and TKN loads, which were 19.0, 12.2, and 6.9 times greater during the first event, respectively.

4.4.3 Total Suspended Solids Trend Analysis

TSS concentrations from 2000 to 2015 were evaluated for normality and log-normal distributions separately for wet and dry weather at each MES using the Shapiro-Wilk test. If the TSS concentrations were normal or log-normally distributed, then a regression analysis was used to evaluate trends. Multiple samples during each monitoring season were treated as replicates. If a normal or log-normal distribution was not found, then it was determined that the distribution of the data was not known. These results were evaluated for trends using the Mann-Kendall non-parametric method. The summary table below presents the method used for trend evaluation and the statistical trend information on TSS data collected at each MES over the past 15 years. The data are shown graphically in Figures 4-13.1 through 4-13.4.

Two significant trends for TSS were identified for wet weather, based on an alpha of 0.05. TSS was identified as a significantly decreasing trend at the Malibu Creek and San Gabriel River MES locations. The TSS trend analysis of dry weather data identified two significant trends based on an alpha of 0.05, including significantly decreasing trends in TSS at the Malibu Creek and Santa Clara River MES (Table 4-11). The p values indicating significant trends are bolded in the tables below.

Trend Analysis of Wet Weather Total Suspended Solids Concentrations at Mass Emission Stations from 2000–2015

Station	p-value	Method	Trend
Ballona Creek at Sawtelle (S01)	0.226	Mann-Kendall	Not significant
Malibu Creek at Piuma (S02)	**0.028**	Regression	Significant decreasing
Los Angeles River at Wardlow (S10)	0.933	Regression	Not significant
Coyote Creek at Spring (S13)	0.426	Mann-Kendall	Not significant
San Gabriel River (S14)	**0.027**	Regression	Significant decreasing
Dominguez Channel at Artesia (S28)	0.107	Mann-Kendall	Not significant
Santa Clara River (S29)	0.056	Mann-Kendall	Not significant

Bold text indicates significant trend ($p < 0.05$)

Trend Analysis of Dry Weather Total Suspended Solids Concentrations at Mass Emission Stations from 2000–2015

Station	p-value	Method	Trend
Ballona Creek at Sawtelle (S01)	0.581	Regression	Not significant
Malibu Creek at Piuma (S02)	**0.006**	Regression	Significant decreasing
Los Angeles River at Wardlow (S10)	0.348	Regression	Not significant
Coyote Creek at Spring (S13)	0.235	Regression	Not significant
San Gabriel River (S14)	0.154	Regression	Not significant
Dominguez Channel at Artesia (S28)	0.687	Regression	Not significant
Santa Clara River (S29)	**0.005**	Mann-Kendall	Significant Decreasing

Bold text indicates significant trend ($p < 0.05$)

4.4.4 Identification of Possible Constituent Sources

This subsection summarizes some of the key points regarding known or suspected sources for each of the constituents that did not meet applicable water quality objectives.

4.4.4.1 Indicator Bacteria

Multiple studies have found urban runoff to be a source of indicator bacteria in the municipal separate storm sewer system (MS4). The SCCWRP conducted bacteria source identification studies of Ballona Creek, and the results were published in 2005 in the journal *Water, Air, and Soil Pollution* (Stein and Tiefenthaler, 2005). In addition, the City of Los Angeles conducted a bacteria source identification study of the Los Angeles River, and the results were published in November 2008. Both of these studies found urban runoff to be a source of indicator bacteria. According to the *Draft Total Maximum Daily Load to Reduce Bacterial Indicator Densities at Santa Monica Bay Beaches* (LARWQCB, 2001b), published on November 8, 2001, urban runoff from the storm drain system may have elevated levels of indicator bacteria as a result of sanitary sewer leaks and spills, illicit connections of sanitary lines to the storm drain system, runoff from homeless encampments, illegal discharges from recreational vehicle holding tanks, and/or malfunctioning septic tanks. Fecal matter from animals, including pets, livestock, and birds, can also be important contributors to elevated bacteria levels. A July 2007 report by ENSR International for EPA New England Region 1, *Mitigation Measures to Address Pathogen Pollution in Surface Waters: A TMDL Implementation Guidance Manual for Massachusetts* (ENSR International, 2007) also discussed the previously mentioned sources.

Bacteria have a strong binding affinity for sediment particles in stormwater effluent. A recent study published in *Environmental Toxicology and Chemistry* examined stormwater particle size distribution in Ballona Creek (Brown et al., 2013). The study suggested that commonly employed best management practices (BMPs) designed to capture larger particles (≥ 250 micrometers (µm)) may not capture the majority of the bacterial contaminant load due to the association of bacteria with small particles (≤ 6 µm).

In addition to bacteria sources, certain factors can amplify bacteria concentrations by promoting bacteria growth. Organic carbon provides food for bacteria. Sunlight can kill bacteria; therefore, covered water can promote bacterial growth. Slow-moving, stagnant water also can promote bacterial growth.

4.4.4.2 Metals

According to the article “Regulating Copper in Urban Stormwater Runoff” (Lee and Lee, 2000), copper may originate from brake pads or industrial (e.g., the textile industry) and mining sources. A metals source study is discussed in the article “Loadings of Lead, Copper, Cadmium, and Zinc in Urban Runoff from Specific Sources” (Davis et al., 2001), which concludes that elevated levels of metals were found from urban areas, especially in highway runoff. The abstract identifies important sources, such as building siding for lead, copper, cadmium, and zinc; vehicle brake emissions for copper; and tire wear for zinc. On January 21, 2015, the EPA, the Environmental Council of the States, and automotive industry signed a copper-free brake initiative to reduce copper in brake pads incrementally to less than 0.5 percent by 2025, joining the states of California and Washington, which implemented the program in 2010. Prior to the signing of these initiatives, an estimated 1.3 million pounds of copper was released into the environment in California in 2010 (EPA, 2015).

Atmospheric deposition has also been identified as an important source of cadmium, copper, and lead. Details behind these findings are presented in the May 2005 Technical Report from SCCWRP entitled *Contributions of Trace Metals from Atmospheric Deposition to Stormwater Runoff in a Small Impervious Urban Catchment* (Sabin et al., 2005). A historic comparison completed by SCCWRP (Sabin and Schiff, 2008) indicated atmospheric deposition sources of copper and zinc have increased near harbor and urban sites over the past 30 years.

4.4.4.3 Sulfate

Elevated sulfate concentrations measured in the Malibu Creek watershed may be at least partially attributable to the Monterey Formation, a natural geologic source of sulfur in the watershed. Large quantities of greenish rock with amphiboles and sediment are found near the Malibu Creek MES within the watershed. The hillside is composed primarily of what appears to be decomposed, somewhat grainy, greenish marine or lagoon sediment/glauconite and less decomposed, greenish-brown shale with clear fossils and embedded detritus. These sediments are known to be sulfur bearing (Orton, 2011). Sulfate levels measured during the comprehensive study outlined in Orton (2011) indicated that water samples from all Malibu Creek tributaries draining the Monterey Formation were above the Basin Plan objective, while none of the tributaries not associated with the formation were above water quality objectives. Lower reaches of the creek, where several tributaries draining different geologic formations combine, varied seasonally from below the Basin Plan objective to well above it. The Monterey Formation may also be a source of other pollutants in the region, such as metals and phosphorus.

Another potential sulfur source may be effluent from the nearby Tapia Water Reclamation Facility, located just upstream from the sampling station. Sulfur is used in wastewater processes such as flocculation. However, other MES near wastewater treatment plants did not show highly elevated sulfur concentrations. Tests and/or a review of effluent reports would be necessary to determine whether effluent from the plant is a significant contributor to the raised sulfur concentrations of these waters.

4.4.4.4 pH

The pH value is a measure of the acid (or H+ ion) concentration in solutions. When the concentrations of acid and base (or OH- ion) are exactly equal, the pH is equal to 7.0. Natural rainwater has a pH of approximately 5.5 (i.e., slightly acidic). As minerals dissolve into rainwater, the pH increases because of the “buffering” effect of minerals such as calcium and magnesium carbonate. Sources that may decrease pH below the water quality objective of 6.5 include illicit discharges (e.g., swimming pools, battery acid, and other light and heavy industrial chemicals).

Six pH measurements during the 2014-2015 monitoring year were above the water quality objective range (basic). A pH above 8.5 could indicate highly mineralized waters; for example, groundwater seepages that are not as diluted, especially during dry weather. These basic readings were all measured during dry weather and were generally only slightly above the water quality objective range. Common human factors that may cause high pH in surface waters include the discharge of concrete wash water, surfactants in cleaning agents, and illicit washing. Algal blooms may also cause elevated pH during the day as they use carbon dioxide for photosynthesis and decreased pH at night as they respire.

One pH value was below the water quality objective (acidic), and this incidence occurred during wet weather. It is possible that sudden rain events can bring the pH below 6.5, if the water sampled is not heavily mineralized. This would be expected in a watershed that is mostly hardscape, with little vegetation to provide detention or interaction with soils. The sudden influx of rainwater is the most likely explanation for the low pH value observed during wet weather.

4.4.4.5 Nitrite

Nitrite is a naturally occurring inorganic ion that is part of the nitrogen cycle. Microbial action in soil or water decomposes wastes containing organic nitrogen into ammonia, which is then oxidized to nitrite and nitrate. Because nitrite is easily oxidized to nitrate, nitrate is the compound predominantly found in groundwater and surface waters. Contamination with nitrogen-containing fertilizers (e.g., potassium nitrate and ammonium nitrate), or animal or human organic wastes, may raise the concentration of nitrate in water. Only two nitrite exceedances were measured during the 2014-2015 monitoring year, one at the Ballona Creek MES (which also had an exceedance during the 2009-2010 monitoring year), and at the Los Angeles River MES (which was only slightly above the water quality objective). Both of these exceedances occurred during the first flush storm event, 2014-15Event04.

Ammonia exists naturally in the environment and is also an important commercial and industrial chemical, according to the New York Department of Health (NYDP, 2008). It is used in agriculture (fertilizers), as a refrigerant, in water treatment processes, in cleaning products, and in the manufacture of many other products including chemicals, plastics, textiles, explosives, and pesticides. One particular source of interest is wastewater treatment plants. According to *Water Supply and Pollution Control*, by Warren Viessman, Jr. and Mark J. Hammer (1998), there is an average of 24 mg/L of ammonia–nitrogen (NH_3-N) in biologically treated domestic wastewater that has not undergone denitrification.

4.4.4.6 Dissolved Oxygen

Aquatic plants photosynthesize to produce oxygen during daylight hours and dissolved oxygen levels also vary with temperature; warmer temperatures decrease dissolved oxygen levels. Therefore, dissolved oxygen levels fluctuate seasonally and temporally. Dissolved oxygen levels also vary spatially, with fast-moving sections of a waterbody containing more oxygen than stagnant or slow-moving water.

A low dissolved oxygen value may indicate that plant or animal waste or other organic matter, often from agricultural use or landscaping, may be present in the stormwater runoff. These organic materials use up the dissolved oxygen (i.e., have a high BOD) as they decompose. If dissolved oxygen levels decline enough, some animals exposed to the reduced oxygen levels may be negatively affected (EPA, 2012).

Thirteen dissolved oxygen values were below the water quality objective during the 2014-2015 monitoring year, all during storm events. Measured BOD values were generally higher in these samples than in those with higher dissolved oxygen values (Appendix B).

4.4.4.7 Cyanide

Sources of cyanide in receiving water samples may include industrial operations such as manufacturing of synthetic fabrics, plastics, and metal processing or electroplating operations. Fumigation operations can also contribute to cyanide in the environment as can commercial printers and pharmaceutical manufacturers. Additionally, incomplete combustion during forest fires may also contribute a large amount of cyanide to the environment. Only one cyanide exceedance (not necessarily due to the sources listed above) was measured during the 2014-2015 monitoring year, during wet weather at the San Gabriel River MES.

4.5 Conclusions and Recommendations

Data collected during the 2014-2015 monitoring year were consistent with those observed during previous monitoring years. During wet weather, nutrients and organics continued to meet water quality objectives at the MES and tributary stations. An exception was nitrite, which was measured above the water quality objective at the Ballona Creek and Los Angeles River MES. The last exceedance of nitrite was measured at the Ballona Creek MES during the 2009-2010 monitoring year. *E. coli*, several dissolved metals (copper, lead and zinc), and pH continued to not meet water quality objectives at several MES and tributary stations during wet weather. During dry weather, dissolved metals, nutrients, and organics continued to meet water quality objectives at MES and tributary stations. *E. coli* and pH occasionally did not meet water quality objectives, and sulfate continued to not meet water quality objectives at most tributary stations and at the Malibu Creek MES.

Long-term trend analysis of the priority constituents in each watershed may provide valuable information regarding evolving watershed conditions. This additional piece of information would assist in management decisions as the County and other agencies move forward under the Watershed Management Programs (WMPs) and Enhanced Watershed Management Programs (EWMPs) developed in accordance with the 2012 Permit. Additionally, field monitoring of DO and pH continue to be incorporated into the monitoring program and will limit the impact of external conditions (sample handling, transportation, water hardness, and alkalinity) on sample results. Sampling guidelines generally call for the measurement of DO as soon as possible after sampling, and measuring pH in the field may limit effects of water hardness and alkalinity on changes to the pH levels measured in the analytical laboratory.

The 2012 Permit provides a watershed management approach to address water quality protection. In accordance with the 2012 Permit, the County of Los Angeles and the LACFCD developed CIMPs for their respective watersheds, through which their monitoring obligations will be met. Most of these CIMPs have been approved, or approved with conditions. The County and the LACFCD are currently awaiting approval of the remaining CIMPs. Assuming the CIMPs are approved prior to the start of the monitoring year, monitoring during the 2015-2016 monitoring year will be conducted under the protocols set forth in those plans.